oxidation of alcohols / reduction to form alcohols

methanol

oxidation

K₂Cr₂O₇ or CrO₃, H₃O⁺

formic acid
(a carboxylic acid)

H-C-H

reduction

formaldehyde
(an aldehyde)

H-C-H

Aldehydes can
overoxidize to
carboxylic acids.

H-C-OH

1° alcohol

oxidizing agents

1. NaBH₄, ROH
2. H₃O⁺

K₂Cr₂O₇ or CrO₃, H₃O⁺

carboxylic acid

H-C-H

sodium borohydride:
Grignard reagent:

PCC

R-C-H

each oxidation step
involves breaking a C-H
bond.

1. RMgX
2. H₃O⁺

potassium dichromate:

K₂Cr₂O₇, H₃O⁺

ketone

H-C-R

In a ketone, the
carbon has no C-H
bonds, so it can't be
overoxidized.

R-C-OH

2° alcohol

lithium aluminum hydride

(LAH):

1. LiAlH₄
2. H₃O⁺

alkyllithium reagent:

PCC

R-C-R

In a tertiary alcohol, the
alpha carbon has no
C-H bonds, so it can't
be oxidized.
reactions involving $\text{H}^-$ and $\text{R}^-$

reaction:

\[
\text{C} = \text{O} \xrightarrow{\text{NaBH}_4, \text{HO}_\text{R}} \text{H} - \text{C} - \text{O} - \text{H}
\]

aldehyde or ketone

alcohol

mechanism:

\[
\text{Na} \xrightarrow{\delta^+ \, \delta^-} \text{H}_\text{3} \text{B}_\text{3} \xrightarrow{\delta^+ \, \delta^-} \text{C} = \text{O} \xrightarrow{\delta^+ \, \delta^-} \text{H} - \text{C} - \text{O} \xrightarrow{\text{Na}} \text{H}_\text{3} \text{O}^+ + \text{BH}_\text{3} \xrightarrow{\delta^+ \, \delta^-} \text{H} - \text{C} - \text{O} - \text{BH}_\text{3} \xrightarrow{\delta^+ \, \delta^-} \text{Na} \xrightarrow{\delta^+ \, \delta^-} \text{H} - \text{C} - \text{O} - \text{H}
\]

In the absence of a protic solvent, this is the final product.

The mechanisms for LiAlH$_4$, RLi, and RMgX are similar, except that the final protonation comes from H$_3$O$^+$ that must be added in a separate step.

stereochemistry: racemic mixture of products (because the H$^-$ can attack either face of the trigonal planar carbonyl group)